REMARKS

Claims 12-22 are pending in this application.

Claims 12-22 are rejected.

In a conventional Magnetic Random Access Memory (MRAM) device including a multitude of spin dependent tunneling (SDT) junction memory cells, certain SDT junctions will be unusable. They might be unusable because they are shorted, inadvertently loose data during write operations, or don't switch to the desired magnetization orientations during write operations.

Unusable SDT junctions can reduce the storage capacity of MRAM devices, and increase the complexity of read and write operations. Large numbers of unusable SDT junctions result in the rejection of MRAM devices, and consequently, increase fabrication cost.

The present invention addresses these problems. According to one aspect of the present invention, an SDT junction includes a bottom ferromagnetic layer, an insulating tunnel barrier atop the bottom ferromagnetic layer, and a top ferromagnetic layer atop the insulating tunnel barrier. The bottom ferromagnetic layer has flattened peaks.

A bottom ferromagnetic layer with flattened peaks has been found to significantly reduce or eliminate ferromagnetic coupling. It has been found that a critical flatness is achieved when the peak-to-valley height difference is no more than about one nm. However, peaks flatter than the critical flatness have been found to increase the FM coupling.

In an MRAM device having a multitude of SDT junction memory cells, bottom ferromagnetic layers having flattened peaks provide additional benefits: improving the uniformity of memory cell resistance across the MRAM device; reducing the number of shorted SDT junctions, and allowing insulating tunnel barrier material to be more evenly over the bottom FM layers, thereby allowing the thickness of the insulating tunnel barriers to be reduced without creating pinholes. Reducing the thickness, in turn, reduces the resistance of the SDT junctions, which can reduce power consumption.

In the office action dated March 25, 2004, claims 12, 16 and 21-22 are rejected under 35 USC §102(b) as being unpatentable over Gallagher et al. U.S. Patent No. 5,640,343; claims 17-18 are rejected under 35 USC §103(a) as being unpatentable over Gallagher et al. in view of Anthony et al. European Patent No. EP0929110A1; and claims 13-15 and 19-20 are rejected under 35 USC §103(a) as being unpatentable over Gallagher et al. in view of others.

All rejections are respectfully traversed. However, only the rejections of independent claims 12, 17 and 21 will be addressed below. Since the independent claims should be allowable over the documents made of record, there is no need to address the rejections of the dependent claims.

Claims 12-16

Claim 12 recites an SDT junction of a memory cell for an MRAM device. The SDT junction comprises a bottom ferromagnetic layer, an insulating tunnel barrier atop the bottom ferromagnetic layer; and a top ferromagnetic layer atop the insulating tunnel barrier. The bottom ferromagnetic layer has flattened peaks.

Gallagher et al. disclose a magnetic tunnel junction 8. The magnetic tunnel junction 8 illustrated in Fig. 1B includes a template layer 15, an initial

ferromagnetic layer 16, an antiferromagnetic layer 18, a fixed ferromagnetic layer 20, a thin tunneling barrier layer 22, a soft ferromagnetic layer 24, and a contact layer 25. The structure of this magnetic tunnel junction 8 is described on col. 4, lines 16-25, and its fabrication is described in col. 5, lines 49+.

Gallagher et al. do not teach or suggest that the peaks of a bottom ferromagnetic layer are flattened or otherwise physically altered.

For some reason, the examiner maintains that Gallagher et al. disclose peaks of a bottom ferromagnetic layer that are flattened or otherwise physically altered. In the previous response, the examiner was respectfully requested to cite the column and line number of a passage where Gallagher et al. describe such peaks. In the present office action, the examiner has not done so. Evidently, the examiner concedes that Gallagher does not explicitly or implicitly disclose peaks of a bottom ferromagnetic layer that are flattened or otherwise physically altered.

All the examiner relies upon is Fig. 1B, and her opinion that "the formation of the tunneling barrier layer will result in the peaks of the ferromagnetic layer being will result in the bottom layer being 'physically altered,' since the tunneling barrier is formed on top of the ferromagnetic layer (see page 10 of the office action). Regarding Fig. 1B, the examiner states "the layer of Gallagher has a valley to peak height variation of zero, which is encompassed in the claimed range of 'no more than about one nanometer.'"

Fig. 1B simply shows a stack of layers. It does not illustrate the surface of any "bottom ferromagnetic layer" in sufficient detail to indicate that peaks are

flattened, or that the surface has a zero variation in height.[1]

The documents made of record do not support the examiner's opinion that depositing the tunnel barrier will flatten the peaks of the underlying ferromagnetic layer. Therefore, it is presumed that the examiner's opinion is based on her personal knowledge. Accordingly, the examiner is respectfully requested, pursuant to MPEP §707 and 37 CFR §1.104(d)(2), to provide an affidavit supporting her personal knowledge that depositing the tunnel barrier will flatten the peaks of the underlying ferromagnetic layer. As part of the affidavit, the examiner should state her relevant job experience in the industry, and indicate whether she has actually tried to fabricate a magnetic tunnel junction.

Absent the affidavit, the documents of record do not support prima facie obviousness of claim 12. Therefore, claim 12 and its dependent claims 13-16 should be allowable over the current documents of record.

Claims 21-22

Claim 21 recites an SDT junction comprising a bottom ferromagnetic layer, an insulating tunnel barrier atop the bottom ferromagnetic layer; and the bottom ferromagnetic layer has physically altered peaks. Claim 21 and its dependent claim 22 should be allowed for the reasons above.

Claims 17-20

Claim 17 recites an array of memory cells, each memory cell including an SDT junction, each SDT junction including a bottom ferromagnetic layer, each

1 Contrast Fig. 1B of Gallagher et al. to Figure 5 of the present application, which is an illustration of a peak-to-valley height difference on the upper surface of the bottom ferromagnetic layer of an SDT junction.

bottom ferromagnetic layer having an upper surface. Each upper surface has a valley-to-peak height variation of no more than about one nanometer.

The examiner acknowledges that Gallagher et al. do not teach or suggest such a valley-to-peak height variation. However, the examiner contends that "Anthony discloses the use of ferromagnetic materials with a thickness of no more than about one nanometer.... It would have been obvious ... to modify the semiconductor device of Gallagher to include the use of ferromagnetic materials with a thickness of no more than about one nanometer..."

The examiner's analysis of Anthony begs the issue. The issue is not whether Anthony's interface layer would have a thickness of about one nanometer, but rather whether Anthony's interface layer would have a valley-to-peak height variation of no more than about one nanometer.

None of the documents made of record suggest that Anthony's interface layer, if deposited on Gallagher et al.'s device, would have has a valley-to-peak height of about one nanometer. The interface layer would be deposited on a pinned ferromagnetic layer. The topography of the interface layer matches the topography of the underlying pinned ferromagnetic layer. Therefore, the interface layer would have the same valley-to-peak height variation as the underlying pinned layer. As the examiner acknowledges, Gallagher et al. do not teach or suggest a surface having a one nanometer peak-to-height variation.

Therefore, the documents made of record do not teach or suggest each bottom ferromagnetic layer having an upper surface with a valley-to-peak height variation of no more than about one nanometer. Accordingly, the '103 rejections of claim 17 and its dependent claims 18-20 should be withdrawn.

The examiner states that the applicants must establish the critical nature of valley to height difference of no more than one nanometer. However, no such requirement exists. The examiner is respectfully request to review MPEP 2144.05, which does not require an applicant to establish criticality of a claimed range, but does allow the applicant to use criticality to rebut prima facie obviousness.[2] However, the examiner has yet to make a showing of prima facie obviousness of claim 17.

Moreover, the '103 rejection has been overcome by a Rule 131 Declaration, which was part of a response submitted October 9, 2002. The Rule 131 declaration included an invention disclosure that was prepared by the inventor. The invention disclosure establishes that the device of claim 17 was actually reduced to practice prior to June 3, 1999.

The publication date of the European patent application is July 14, 1999, which makes it prior art under 35 USC 102(a). However, the Rule 131 Declaration establishes prior invention (June 4, 1999).

The filing and issue dates of corresponding U.S. Patent No. 6,169,303 are Jan. 6, 1998 and Jan 2, 2001. Therefore, the '303 patent is a '102(e) reference. However, the '303 patent and the present application are commonly owned, therefore, the '303 patent can't be used in a '103 rejection. For this additional reason, prima facie obviousness of claim 17 has not been established.

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2 In fact, the application does establish the criticality of this one nm height diff rence: it has been found to significantly reduce FM coupling (s e p.8, lines 20-24 of the application).

'112 rejections

Claims 13 and 19 are further rejected under 35 USC §112, second paragraph as being indefinite. This rejection is respectfully traversed. The examiner argues that the claims are indefinite because it is not clear where the "angle is formed." This rejection is puzzling, since each claim recites "wherein angle from the top of a grain to an intersection with an adjacent grain is between about three and six degrees."

The examiner argues that the term "grain" lacks antecedence and "what and/or where are the grains in the structure of the junction or device." This argument is also puzzling, since both claims recite "a grain" (as opposed to "the grain") and since the angle (Θ) and grains are clearly shown in Figure 5. This brings into question the examiner's understanding of antecedence. The examiner is respectfully requested to review MPEP 2173.05(e).

Objection to Figure 2

The examiner objects to Figure 2 because "it is not clear where 44 and 42 are supposed to be located because there is no line connecting the reference numerals to the drawing. The examiner further states that the objection will not be held in abeyance.

The undersigned is not requesting and has not previously requested abeyance of this objection. Rather, the undersigned is traversing and has previously traversed the objection. All three reference numerals (40-44) correspond to the black bar, which represents an insulating tunnel barrier and interfacial layers. The specification describes where 42 and 44 are located.

The examiner has yet to present a legal basis for this objection. No passages in the MPEP, CFR or US Code have been cited to requir a leader line

for each reference numeral. If the examiner can establish a legal basis for this objection, the undersigned will gladly comply and submit new drawings.

The examiner is respectfully requested to review the case file of parent application U.S. Serial. 09/514,934, now U.S. Patent No. 6,727,105.

Conclusion

The examiner is respectfully requested to withdraw the rejections of claims 12-22 and issue a Notice of Allowability. If any issues remain, the examiner is invited to contact the undersigned to discuss those remaining issues.